



Uniform Gas Cushion Wafer Support

Technical Field

The invention relates generally to the field of semiconductor wafer processing and more specifically to a vertical rapid thermal processing unit that includes a gas cushion wafer support assembly for positioning a wafer within the processing unit.

Background of the Invention

Thermal processing systems are widely used in various stages of semiconductor fabrication. Basic thermal processing applications include chemical deposition, diffusion, oxidation, annealing, silicidation, nitridation, and solder re-flow processes. Vertical rapid thermal processing (RTP) systems have a vertically oriented processing chamber that is heated by a heat source such as a resistive heating element or a bank of high intensity light sources. An elevator tube is controlled to move a wafer on a wafer support vertically within the processing chamber. In some RTP systems, the heat sources create a temperature gradient within the processing chamber and temperature ramp-up and ramp-down rates of the wafer being processed are controlled by the vertical location of the wafer within the processing chamber. Therefore, to optimize the thermal processing of semiconductor wafers it is important to accurately control the position of the wafer within the processing chamber.

Prior art wafer supports, such as shown in Figure 1, use pins, rings, or other hard surfaces to support the wafer during thermal processing. The prior art systems give rise

to local contact type stresses and bending stresses. The silicon wafer yield strength decrease as a function of temperature. When the yield strength reaches the bending stress, microcracks may occur within the silicon crystal structure. This is detrimental at the point the wafer contacts the mechanical support. As processing temperatures increase, the potential for deformation becomes more significant.

Summary of the Invention

A gas cushion provides uniform support for a workpiece being processed. To achieve the gas cushion, a plenum featuring a workpiece support flange is connected to a gas supply. When a workpiece is placed on the support flange and gas is supplied to the plenum, the inner diameter of the support flange coacts with the workpiece edge to define a gas flow path through which the supplied gas flows when the workpiece is lifted from the support flange. An edge ring may contact a workpiece edge and define the gas flow path in conjunction with the support flange. Loading structure may be associated with the plenum to separate the workpiece from the plenum for loading or unloading the workpiece from the plenum. The loading structure may feature pins that protrude through the plenum and contact a process chamber surface to be pushed toward and lift the workpiece when the plenum is in a position for loading or unloading.

Brief Description of the Drawings

Figure 1 is a perspective view of a prior art wafer support system;
Figure 2 is a cross sectional view of a rapid thermal processing unit suitable for practice of the present invention;

Figure 3 is a perspective view of a gas cushion wafer support with a section removed to illustrate various features;

Figure 4 is a cross section view of an alternative embodiment of gas cushion wafer support; and

Figure 5 is a cross section view of the gas cushion wafer support of Figure 3 in a wafer load position.

Detailed Description of the Preferred Embodiments

Figure 2 illustrates a rapid thermal processing system 10 that uses a cylindrical hot wall system to thermally process semiconductor wafers. A wafer 12 is placed on a gas cushion wafer support 13 (shown in more detail in Figures 3-5) and is moved vertically through a process chamber having a temperature gradient created by heating elements behind the chamber walls as shown in phantom. The wafer support 12 is connected to an elevator tube assembly 18 that protrudes through an orifice in the chamber floor. The elevator tube is connected to a moveable carriage 25 that traverses a set of rails 26 to move the elevator tube 18 and wafer support 12 along a vertical excursion within the process chamber 15. A gas curtain is created within the gap between the outer diameter of the elevator tube and the orifice to prevent the passage of ambient air into the process chamber.

Referring now to Figure 2 one embodiment of the gas cushion wafer support 13 is shown in more detail. A gas cushion plenum 30 is mounted to the top of the hollow quartz tube 18 and has an inlet orifice through which gas is supplied to the plenum through the quartz tube. Three wafer loading pins 45 slideingly protrude through the

bottom of the plenum 30. Wafer cushioning plugs 43 on the top of each pin 45 seal the plenum when the support is moved through the processing chamber as well as provide a cushion interface between the pins and the wafer (see Figure 4). When the bottom of the plenum 30 is in close proximity to the bottom of the processing chamber, the pins are pushed toward the workpiece as shown in Figure 5 to lift the wafer above the plenum for unloading by a robotic arm (not shown). When the gas cushion is not activated, the wafer is supported by a support flange 34 that has an outer diameter slightly larger than the outer diameter of the wafer and located on the support flange by a locating wall 32.

Figures 3 and 4 illustrate a gas cushion wafer support 13 that includes an edge ring 39 that rests on the support flange 34. The edge ring has a much smaller mass than the wafer 12 and a slightly larger outer diameter than the wafer. The edge ring 39 damps the convection cooling effect from gas flowing through the annular orifice. The edge ring 39 also damps the effect of radiation heating from the heat source. Damping both of these effects near the wafer edge maintains a more uniform temperature across the wafer surface.

Figure 5 shows a wafer 12 as it is positioned when it is first loaded onto the support 13. The robotic arm places the wafer on the loading pins 45. The quartz tube 18 then begins its upward excursion in the process chamber. As the support 13 moves away from the floor of the process chamber, the pins 45 drop through the bottom of the plenum 30 and the wafer rests on the edge ring 39 that in turn rests on the support flange 34 (see Figure 4). When the wafer 12 is lowered into the plenum gas flow through the quartz tube then begins and the gas pressure increases in the plenum until the wafer floats. Process chamber gas continuously flows through the interior 19 of the quartz tube and

into the plenum 30. When the plenum 30 is becomes sufficiently pressurized with gas, the pressure lifts the wafer 12, and the edge ring 39 if it is used, and the gas escapes the plenum through a gap 37 between the wafer edge (or edge ring) and the support flange. As long a the supply gas flow is sufficient, the pressure will equalize at a level such that the wafer floats above the flange on a cushion of gas.

As can be seen from the foregoing description, the gas wafer support provides a uniform cushion for supporting a wafer during processing. Although the present invention has been described with a degree of particularity, it is the intent that the invention include all modifications and alterations from the disclosed design falling within the spirit or scope of the appended claims.